Monitoring forage production with MODIS data for farmers' decision making

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INTRODUCTION

In grass feeding livestock production systems, seasonal forage production has to be known to rationally set the stocking rate, prevent possible food shortages, and evaluate efficiencies yielded by different management strategies. Farmers do recognize this need, but traditional difficulties in assessing forage production force them to use coarse estimations. We developed a near real-time estimation system of aerial net primary production (ANPP) at a within-paddock level for different forage resources under real-farm conditions. The system is already delivering monthly estimates of ANPP to a consortium of 25 farms summing 29000 ha in SW Buenos Aires province, Argentina (Fig 1).

In this work, we present the basis of that system and its first results.

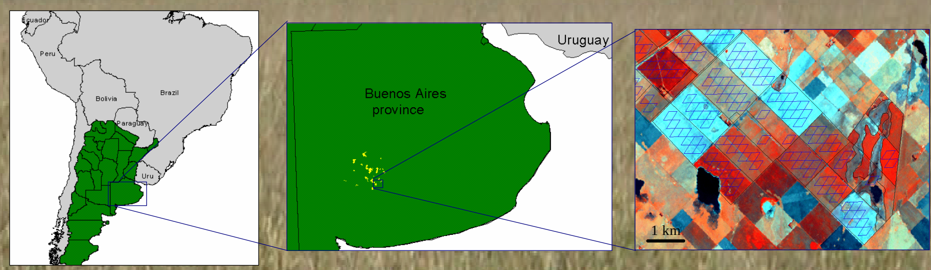


Figure 1. Detail of MODIS pixels included in the paddocks of one of the 25 farms under study in SW Buenos Aires province, Argentina.

METHODOLOGY

We derive the fraction of absorbed photosynthetic active radiation (*f*PAR) from the normalized difference vegetation index (NDVI) for every 250 m MODIS pixel completely included in the paddocks (Fig 1), assuming a non-linear relation between *f*PAR and NDVI (Fig 2; Potter *et al.* 1993). *f*PAR could take values between 0 (for bare soil) and 0.95 (maximum interception).

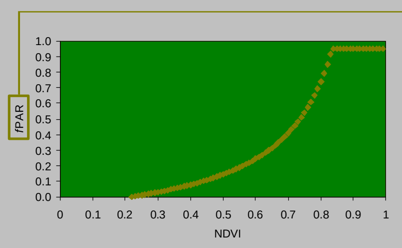


Figure 2. Relationship used to derive *f*PAR from MODIS NDVI.

Then, we calculate the absorbed photosynthetic active radiation (APAR) using incoming photosynthetic active radiation measurements from a meteorological station.

$$fPAR \; * \; PAR \; = \; APAR$$

From a 25 km-far meteorological station

APAR integrates variations in climatic and vegetation conditions (Fig 3) and represents the solar energy effectively conducted to vegetation growth.

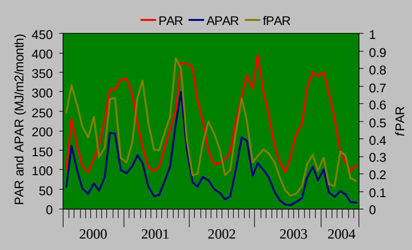


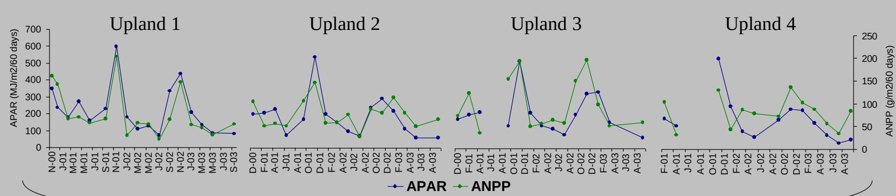
Figure 3. Averaged pattern of incoming PAR, *f*PAR and APAR for sown pastures of SW Buenos Aires province.

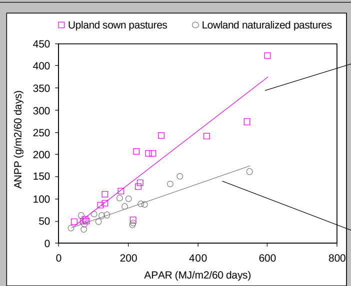
Finally, we calculate ANPP using radiation use efficiency (RUE) values empirically estimated for the two principal forage resources: upland sown pastures and lowland naturalized pastures. These calibrations were based on ground measurements of ANPP for 2-month periods between October 2000 and October 2003, and the respective APAR.

RESULTS

Basis of the system: RUE calibrations

The empirical relation between ANPP and APAR was different between resources (Fig 4) but almost identical among different sites of the same resource. For upland, sown pastures it was ANPP=0.6*APAR+12, (R^2=0.86; n=18), and for lowland, naturalized pastures it was ANPP=0.27*APAR+26, (R^2=0.74; n=18), with ANPP in g/m²/60 days and APAR in MJ/ m²/60 days. These models were used to derive ANPP from APAR.





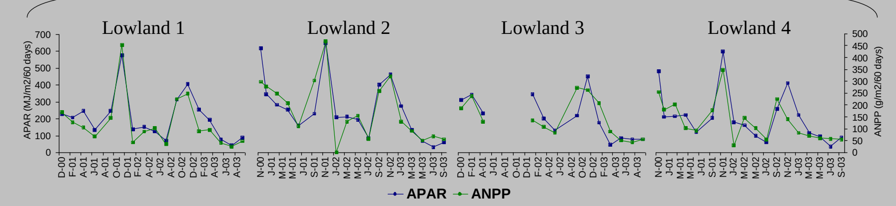


Figure 4. Calibration between APAR and ANPP. The upper figures are four upland sown pasture sites and the lower are four lowland naturalized pasture sites.

RESULTS

First set of estimations

Patterns of monthly estimates of ANPP from February 2000 through July 2004 showed that upland, sown pastures were much more productive than lowland, naturalized pastures, specially in spring, when usual good climatic conditions allow upland, sown pastures to express their potential rate of growth (Fig 5). Average annual production was 7614 kg/ha for upland, sown pastures, and 4099 kg/ha for lowland, naturalized pastures. However, both forage resources showed a similar seasonal pattern: a peak in spring, a drop through summer, then a year-dependent slight peak in autumn, and a less productive period during winter.

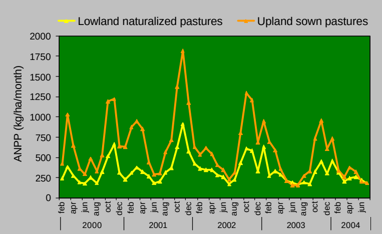


Figure 5. Monthly estimates of ANPP from Febrary 2000 to July 2004 for three different forage resources.

ANPP during July 2004, last month, was similar to that in 2003, but relatively low in comparison with the years before (Fig 6).

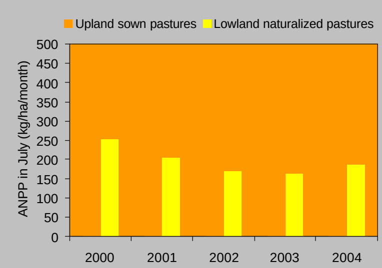


Figure 6.

ANPP among different paddocks having the same resource also varies considerably (Fig 7).

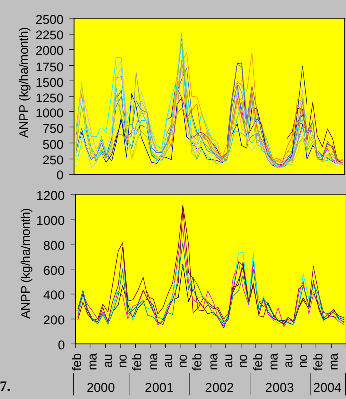


Figure 7.

CONCLUSIONS

Our first set of estimates was presented to the farmers for them to compare with their own perceptions of relative differences among paddocks. In this sense, farmers found the estimates very good. They found particularly valuable the information that our system provided on inter-paddock production differences, the rate of production decline with pasture age, which allows them to make decision on rotations, and the range of production variation associated with particular climatic events.

In the near future, we expect to improve the accuracy and reduce the local component of our system by incorporating a more mechanistic approach for the estimation of RUE. We also face the challenge of incorporating this novel, fine-scale monitoring of ANPP into the decisional framework of these farmers.

Bibliography

Potter, C.S., J.T. Randerson, C.B. Field, P.A. Matson, P.M. Vitousek, H.A. Mooney, and S.A. Klooster. 1993. Terrestrial ecosystem production: a process model based on global satellite and surface data. Global Biogeochemical Cycles 7:811-41.

Acknowledgements

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